



Food System
Economics
Commission

WORKING PAPER

Enhancing Domestic Food Processing for a more Sustainable Food System in Benin

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ACKNOWLEDGEMENT

This work has been supported by the Food System Economics Commission, funded by the IKEA Foundation, grant agreement no. G-2009-01682..

CITATION

Kinkpe, A.T. & Grethe, H. (2023). Enhancing domestic food processing for a more sustainable food system in Benin.

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Enhancing domestic food processing for a more sustainable food system in Benin

Final Report, 17. April 2023

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1. Introduction

The development of processing agricultural products has huge potential for enhancing the sustainability of food systems. More and better food processing can contribute to waste reduction, food security, availability of diverse products with high nutritional value, demand for agricultural products and income generation closely linked to the agricultural sector and often in rural areas.

Agriculture and food are highly relevant in Benin: Agriculture has a share of 33% of the GDP and about 70% in employment (MAEP, 2017) and food expenditure is about 41% of private household income (Grethe *et al.*, 2020). About 10% of the population is food insecure according to Le Défis Faim Zéro (2018). The food processing industry is a highly relevant bottleneck for many raw agricultural products. For example, a high share of chicken meat demand is covered by imports of frozen chicken meat from Europe, as domestic value chains including slaughtering and processing facilities are not well developed (Kulla *et al.*, 2021). Another example are cashews, which are predominantly exported as a raw product since the processing industry is not competitive compared to the main export destinations in southeast Asia (Houngbédji, 2020).

In this study, chicken meat and cashews will serve as examples for demonstrating the relevance of developing downstream sectors to improve agricultural and other rural livelihoods. The following paragraphs outline the reasons why both products are relevant for a sustainable food system in Benin.

Poultry: Overall, the meat consumption level in Benin is low: about one-quarter of the level of high-income countries according to official statistics, about 14% if corrected for informal trade. The most important meats consumed in Benin are poultry and beef (see Table 1). Beef accounts for about 40% of total meat consumption and most of it is produced domestically. Poultry meat accounts for about 30% of total meat consumption and more than half of it is imported (Table 1). As documented in USDA (2014), about 85% of poultry meat imported to Benin is exported, most of it informally smuggled to Nigeria with almost no official data record. Therefore, poultry meat consumption per year accounts only for about 3 kg per capita per year compared to the 10 kg officially reported.

Table 1: Meat supply and use (average 2018/2019)

Meat	Production (1000 t)	Consumption (1000 t)	Export (1000 t)	Import (1000 t)	Self suff. (%)	Per capita (kg/year)	Per cap. adult equ. (g/day)
Meat total (official)	82	188	14	117	44%	16.1	50.7
Meat total (corrected)	82	104	99	117	79%	9.3	27.9
Poultry meat	15	117	14	117	13%	10.1	31.6
Poultry meat (corrected)	15	33	99	117	46%	2,8	8.8
Beef	42	45	0	0	95%	3.8	12.1
Other meat	25	26	0	0	97%	2.2	7.0

Source: FAOSTAT (2021), USDA (2014), World Bank (2021), own calculations.

Willett *et al.* (2019) propose a healthy average global diet that ensures staying within planetary boundaries. They suggest 7 g of beef and lamb, 29 g of poultry meat and 7 g of pork per adult per day, summing up to 43 g in total.

The Benin adult-equivalent population in 2019 was estimated at 10,155,813 persons (World Bank, 2021). The last column of Table 1 shows that the average actual poultry meat intake per adult in Benin is far lower than the suggestions by Willett *et al.* (2019), while the beef and lamb meat (contained in “other meat”) intake is higher.

Poultry is among the less expensive sources of protein with relatively low GHG emissions per kg of protein due to the good feed conversion. In particular, GHG emissions related to beef production, the other major meat in Benin, are much higher. In addition, well-developed processing chains would reduce health risks due to hygienic issues resulting e.g. from the importation of frozen chicken parts, representing most of Beninese imports. Despite low production compared to imports, poultry farming is a complementary income source for about 84% of smallholder farmers (Kherallah *et al.*, 2001). In Benin, three poultry production systems can be distinguished. Traditional, semi-modern and modern (Kulla *et al.*, 2021). The traditional system produces about two-thirds of the total production while the semi-modern and modern systems produce together about one-third (Fanou, 2008). Traditional and semi-modern systems are raising mostly traditional breeds. In the traditional system which is practiced by almost all rural households, no antibiotics are used. The animal diet consists of kitchen waste and harvest residues. In the semi-modern system, some extra feed is provided. The modern system, producing mostly imported breeds, is not industrialized. The size of the herds is relatively small (typically 1000-5000 heads). Labor is used intensively. In light of the low per capita meat consumption level in Benin (less than 20% of e. g. Germany), the good feed conversion rates and the potentially widely spread income effects of small to medium size farms, poultry sector development can be considered an example for a transformation

towards sustainable protein sources. It would also bring Benin closer to the healthy and sustainable diet proposed by Willet *et al.* (2019).

Cashew: In 2019, about 130,000 tons of cashew nuts were produced in Benin (Aguehoude, 2020), mostly (98%) in the north and in the center of the country (Issaka, 2019). Currently, the industry is to a large extent only using the cashew nut, which is predominantly (81%) exported raw (Houngbédji, 2020). In addition, most of the produced cashew kernels (an output from the processing of 19% of raw cashew production) are also exported. Industrial processing of about 1000 tons of cashew nuts provides about 417 million FCFA (US\$ 710,805) of added value (Houngbédji, 2020). Using by-products more intensively would enhance the competitiveness of the processing sector, generate extra income for farmers, save resources by using waste for food production and contribute to human health: the cashew apple is a healthy food with a high nutrient content which is typically used to produce cashew juice. Currently, cashew juice is being consumed within the country, but there is an opportunity to meet additional demand both domestically and on export markets. For a healthier diet (at most 31 g of added sugar per adult per day according to Willet *et al.*, 2019), domestic marketing should aim at replacing industrial soft drinks (with very high sugar content) rather than other juices.

The cashew shell can be used for the production of bioenergy together with residuals from cashew apple processing to save fossil energy sources. This bioenergy would be non-tradable and used locally. Against the background of the unstable national energy network, this energy source may benefit the competitiveness of national cashew processing. Cashew is an export product, where the use of by-products from processing may improve rural livelihoods through income (most of the production is in vulnerable areas (WTP, 2014)), positive health effects (nutrient-rich juice replacing e.g. sugar-rich soft drinks) and local energy supply (Houssou *et al.*, 2018). Currently, most cashew apples spoil under the trees (Dedehou, Dossou and Soumanou, 2015). In conclusion, the development of cashew processing is an example of the transformation of food systems towards the creation of complex and multifunctional value “networks” instead of chains addressing food and energy needs, waste reduction and micronutrient provision.

This research project aims to analyze options for enhancing domestic food processing for two value chains (poultry meat and cashew) in Benin and to demonstrate the economy-wide relevance of improving the processing sector for the development of a sustainable food system. To achieve this objective, we rely on two methods:

1. **Case studies:** These are based on a literature review and sector surveys among poultry meat producers and processors and cashew producers and processors. **Rationale:** An in-depth understanding of the current regional, local and farm context-specific state as well as bottlenecks for further development is essential for any further analysis of governance options for enhancing the processing sectors.
2. **Economy-wide simulation model analysis:** Development of a social accounting matrix (SAM) and a Computable General Equilibrium (CGE) model to depict the sectoral and economy-wide implications of enhanced food processing. **Rationale:** While many efforts are made to depict the agricultural sector well in economy-wide models, the processing sector is often highly aggregated and not well developed. Such aggregation fails to capture the specific development challenges at hand and limits the ability to analyze the impacts of processing development.

Three specific activities are conducted: i) disaggregation of an existing Social Accounting Matrix (SAM) for Benin in the relevant dimensions, ii) sector surveys, iii) CGE development and scenario analysis.

An additional outcome of the project which we did not envisage originally is the Human capital formation. We recruited two master students in Benin: one researching on poultry processing and the other on cashew apple processing.

2. Empirical studies

Three surveys were organized in Benin: unstructured interviews with poultry processors as well as cashew processors and farmers and a structured consumer survey (experimental auction) on cashew juice.

2.1. Poultry slaughtering in Benin

There are two kinds of poultry slaughtering in Benin. The first kind is the provision of slaughtering services. In different markets, there are people providing slaughtering services to consumers buying living chickens. Those kinds of slaughters are not considered here as poultry processors.

The second kind of poultry slaughtering involves processing into meat (estimated at about 300 tons of meat in 2019) and selling the meat in different forms. Such processors process about 0.5% of total domestic poultry production, come in various legal forms and are mostly located in the south of Benin where the biggest population centers are. More than 99% of total domestic poultry production is purchased and consumed directly by consumers without intermediate processing steps (Kinkpe *et al.*, 2022). We collected data from 11 processors. They sell either the entire bird or pieces according to market demand. Apart from chicken, which is the major poultry product processed, they also process guinea fowl, quail, duck and turkey.

2.1.1. Market

According to poultry processors, local poultry meat demand is very high compared to supply. Consumers prefer it because it is local poultry, tastes far better and is considered “natural” compared to imported frozen chicken parts. A typical statement of a processor we met is: *...the local poultry meat is more delicious than imported frozen meat. Even if the local poultry meat is frozen, the taste is still good...* Processed local chicken as well as imported chicken is ready to cook allowing consumers who do not have time to do the slaughtering and related activities themselves to also eat local poultry. The fact that most of the local poultry is not ready to cook is one of the reasons why urban consumers would buy imported frozen chicken, regardless of potential health and sustainability problems.

2.1.2. Strength, weakness, opportunity and threat in poultry processing

The Strengths, Weaknesses, Opportunities and Threats (SWOT) of the poultry processing sector as felt by processors are presented in Table 2.

Table 2: SWOT analysis of the poultry processing sector in Benin

Strengths <ul style="list-style-type: none"> • Good command of processing technology (professionalism, hygiene, speed, care, availability of processing tools) • Availability and devotion of farmers • Economically profitable activity • Quality of the meat • Preference of consumers for bicycle poultry • Available labor • Diversity of products from poultry processing • Synergy among the value chain actors • Some have already been certified by <i>Solidarités Entreprise Nord-Sud</i> (Solidarity Enterprise North-South, SENS) BENIN 	Weaknesses <ul style="list-style-type: none"> • Lack of suitable (efficient) equipment • The poultry value chain is not yet well mastered • Low willingness to pay of consumers • Chicken shortages during certain periods (there are periods when demand cannot be met) • Lack of stable electricity • Lack of adequate transport causing too high mortality during transport • Lack of skilled labor • Lack of awareness among the population about availability of ready-to-cook local poultry meat
Opportunities <ul style="list-style-type: none"> • Several projects supporting the sector in the country • Existence of demand • Promotion of local products by the government 	Threats <ul style="list-style-type: none"> • Competition from cheap imported frozen chicken meat mostly of low quality • Lack of strong political decisions to prevent or limit poultry meat import

Source: Own compilation based on survey data.

2.1.3. Challenges

According to processors, the main challenge in poultry processing in Benin is to make consumers aware that ready-to-cook poultry meat is available in Benin. This would allow them to shift their demand from imported frozen to local poultry meat. After satisfying the domestic market, processors would like to export at least to neighboring countries, especially Nigeria, where a substantial share of the imported frozen poultry meat is smuggled to. Conditions mentioned for such exports are i) meeting international standards for meat trade and ii) governmental support to facilitate that trade.

Processors also think that cost-saving chicken farming technologies would be needed to increase price-competitiveness of local vis-à-vis imported products.

2.1.4. Political options for sector development

According to the processors, the government can support the domestic poultry meat sector development by:

- i) Higher tariffs on imported frozen poultry meat,
- ii) Higher quality requirements for imported frozen poultry meat,
- iii) Better extension services to poultry farmers regarding cost-saving production technology,
- iv) Subsidizing the processing sector,
- v) Promoting local poultry meat through marketing strategies to make consumers aware of potential health implications of imported frozen meat.

2.2. Cashew apple processing in Benin

Currently in Benin, 25 cashew apple processors are known, taking different legal forms such as individual enterprises or cooperatives. We collected data from three individual enterprises (one in Dassa, one in Glazoué and one in Djougou) and two cooperatives (one in Ouessè and one in Parakou) whom we consider to be representative. The differences between cooperatives and individual enterprises are mainly in management. The cooperative members are the workers. In general, they do not employ other people. Individual enterprises and cooperatives use the same technology. In terms of the quantity processed, the individual enterprises that we met process larger quantities than the cooperatives that we met.

Cashew apple processors are already producing four types of cashew apple products in Benin: juice (Picture 1), wine (Picture 2), whiskey (Picture 3) and honey. Two categories of juice exist. The first is just pasteurized after extraction and called “natural flavored” by the processors while the second is heated strongly for a relatively long time and is called “caramel flavored”. When the heating process continues for a longer time, most of the water in the cashew apple juice evaporates, leaving a honey-flavored sticky product called “cashew honey”. Wine and whiskey are obtained from alcoholic fermentation of the juice. The whiskey in picture 3 is a creamy whiskey, the cream of which is made from cashew kernels. However, cashew whiskey can also be without cream and only from the cashew apple. The cooperatives that we met focus on juice while the individual enterprises innovate more with several cashew apple products.

Picture 1: Cashew apple juice



Picture 2: Cashew apple wine



Picture 3: Cashew whisky



According to processors, the cashew apple has a lot of potential as a high diversity of products can be derived from it. One processor said “...as a processor, you never lose your stock of cashew apples. If you mistake the juice production, you may obtain honey. If you are not satisfied by the juice after extraction, you can leave it to ferment turning into alcohol etc...”.

2.2.1. Market

Cashew juice from Benin is not only sold on the domestic market, but also exported to West-African countries and the European Union (EU). Domestic demand is not well developed because most consumers are not even aware of the existence of these products. While alcoholic cashew apple drinks are almost 100% domestically consumed, about 45% of the cashew apple juice is exported.

2.2.2. Strength, weakness, opportunity and threat in the cashew apple processing

Table 3 presents the Strengths, Weaknesses, Opportunities and Threats (SWOT) of the cashew apple processing sector as felt by processors.

Table 3: SWOT analysis of the cashew apple processing sector in Benin

Strengths <ul style="list-style-type: none"> • Availability of cashew apples at a relatively low price • Extremely rich and balanced food (rich in vitamin C, magnesium, potassium, calcium, iron) • Economically profitable activity • Certification of processing units concerning norms and quality is available • Good command of processing technology 	Weaknesses <ul style="list-style-type: none"> • Cashew apples are highly perishable (the harvested apple should be processed the same day) • Lack of adequate transportation means for cashew apples • Cashew apple products are not well-known by consumers • Myths about cashew apples (consumer concerns about the product) • The corrosivity of cashew apple juice requires stainless equipment • Lack of skilled labor for maintaining equipment • Lack of electricity
Opportunities <ul style="list-style-type: none"> • Several projects supporting the sector in the country • The juice is highly appreciated on the international market • A factory for bottle production is currently installed in the Glo Djigbé Industrial Zone (GDIZ) 	Threats <ul style="list-style-type: none"> • Climate change influencing the yield and the quality of cashew apples • Competition from cheap Nigerian soda

Source: Own compilation based on survey data.

2.2.3. Challenges

Electricity is lacking in most of the processing units. To cope with this, combustion engines are used. However, for some activities such as packaging, electricity is needed. For cooking, either firewood or gas is used.

In addition, the cashew apple processing is difficult. The harvested cashew apple needs to be completely processed the same day, otherwise it tastes differently.

2.2.4. Political options for sector development

According to processors, the government should support making the population aware of cashew apple products and their health effects. They also suggest the expansion of the electric network so that most of the processing units can be connected. Another important suggestion is to train cashew farmers for the primary juice extraction (using combustion engines) from the cashew apple. Afterwards, relatively big factories can collect these raw juices for final processing in the nearest city as the transportation of that raw juice is far easier than the transportation of the cashew apple. Furthermore, processors would like public and private institutions to prioritize the use of domestic products during national events such as conferences and forums for more domestic demand.

2.3. Cashew farmers talking about cashew apple in Benin

We collected data from farmers in Savalou, Glazoué, Ouessè, Tchaourou and N'Dali. In total, data are collected from 41 farmers using unstructured interviews.

Only one of them (in Ouessè) also belongs to a processing cooperative, processing less than 1% of his cashew apples. Only a few of them sold at least once, a really small share of their cashew apple for processing.

Most cashew farmers are aware that cashew apples can be processed into juice and alcohol. They do not know the processing technologies but argue that processors can take up big quantities. Consequently, cashew apple processing is taking off in Benin, but still at a very low level. Most cashew apples are still perishing, which is why farmers argue that the raw material is available at almost no cost for processing. If they can be trained or organized in partnerships with processors, they may benefit from the opportunity of cashew apple processing.

2.4. Cashew juice consumption in Benin

Experimental auctions on cashew apple juice consumption were conducted, as this method allows putting consumers into actual market conditions and limiting biases (Robin, Rozan and Ruffieux, 2008). The method is based on the paradigm of consumer rationality: an individual will offer more for a good which provides more utility to him/her (Robin, Rozan and Ruffieux, 2008; Demont, Rutsaert, Ndour and Verbeke, 2013; Demont, Rutsaert, Ndour, Verbeke *et al.*,

2013; Demont, Fiamohe and Kinkpé, 2017). This section summarizes the sampling and the auction procedures as well as the results.

2.4.1. Sampling

The experiments cover all of Benin geographically. In each of the four regions of Benin (south, centre, northeast and northwest), the capital city (regarding the availability of public infrastructure and the presence of public administration) was selected. Likewise, a village was selected in the neighborhood of each selected city. Data were collected in the following municipalities: Cotonou and Abomey-Calavi (south); Bohicon and Djidja (centre), Djougou and Natitingou (northwest); Parakou and N’Dali (northeast). In total, 265 consumers were sampled.

Consumers were randomly selected for each auction session. Selected consumers were men and women who are at least 18 years old and able to represent their household. In each city/village, we randomly selected a road. We walked near that road and asked eligible people passing by if they would like to participate in our experiment after briefly explaining to them the experiment (without providing details which may influence the result, e.g. we were promoting local products, cashew products or...). Those who accepted were guided through the process which lasted no more than 30 minutes.

Almost half of the surveyed consumers live in rural areas and almost 60% are male (Table 4). The total sample aimed at per region was 60 consumers. In the southern and the central regions, we sampled more because the data collection started in these regions and we first did some training trials so that the enumerators got acquainted with the process. Later on, we noticed that most of the data collected as trials were good to use. This explains the difference in the sample size for the southern and central regions.

Table 4: Consumers’ sample by urbanization, gender and region

Regions	Rural			Urban			Region		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
South	20	20	40	6	31	37	26	51	77
Centre	10	21	31	22	15	37	32	36	68
Northeast	12	17	29	17	14	31	29	31	60
Northwest	14	15	29	12	19	31	26	34	60
Total	56	73	129	57	79	136	113	152	265

Source: Own compilation based on survey data.

2.4.2. The auction procedure

The two existing juice types were presented separately to consumers. For each auction session, data collection comprised three rounds: pre-sensory (round 1), post-sensory (round 2) and post-group-discussion (round 3). The pre-sensory auction allows analyzing consumer choices and willingness to pay (WTP) before tasting the product. The post-sensory phase targets to measure the effect of the taste on consumer choices and WTP. The post-discussion aims at checking whether Word-Of-Mouth (WOM) may be used as a marketing strategy.

The processors' survey shows that the average production price is about FCFA 235 for 25 cl of juice (FCFA 940/l). We used this price as a benchmark. A procedure close to the “**endow-and-upgrade**” procedure was used (Demont, Rutsaert, Ndour and Verbeke, 2013; Demont, Rutsaert, Ndour, Verbeke *et al.*, 2013; Kinkpe *et al.*, 2022; Demont, Fiamohe and Kinkpé, 2017). In the “endow-and-upgrade” procedure, consumers are endowed with the benchmark which is put in competition with all alternatives. This can be costly. Therefore, we applied a procedure that we call “**know-and-upgrade**”. Consumers were informed about the existence of cashew juice with lower quality and price (benchmark price). In each round, consumers selected between buying or not the better-quality cashew juice presented to them. If they want to buy, what is the maximum amount (WTP) they would add to the benchmark price? And will they decrease the consumption of other drinks or not? If they do not want to buy, will they buy the lower quality one? If yes, is this because of the price? Are there other reasons? If they do not want to buy cashew juice at all, why? As in real auctions, the bids were confidential for each consumer. At the end of a session, we asked each consumer to select the juice they preferred among the two we presented to them. To avoid advertisement for a brand or a factory and a bias of choices, the juices used were unlabeled.

We calculated Taste premiums and WOM premiums as follows. Let WTP_{ijr} be the WTP of the consumer i for juice type j during round r ($r = 1$ for pre-sensory round, 2 for post-sensory round and 3 for post-discussion round). Taste premium T_{ij} and the WOM premium W_{ij} paid by the consumer i for the juice type j are calculated as:

$$T_{ij} = \frac{WTP_{ij2} - WTP_{ij1}}{P^0} \quad (1)$$

$$W_{ij} = \frac{WTP_{ij3} - WTP_{ij2}}{P^0} \quad (2)$$

where P^0 is the benchmark price of the cashew juice, WTP_{ij1} is the WTP paid by the consumer i for the juice type j during the pre-sensory round (round 1), WTP_{ij2} is the WTP of the

consumer i for the juice type j during the post-sensory round (round 2) and WTP_{ij3} is the WTP of the consumer i for the juice type j during the post-discussion round (round 3).

2.4.3. Results: Awareness of consumers about cashew juice and consumption

Almost 90% of the 265 consumers that we met did not know that cashew juice exists in Benin (Figure 1) and less than 30% of those who know, consumed it at least once. (Figure 2).

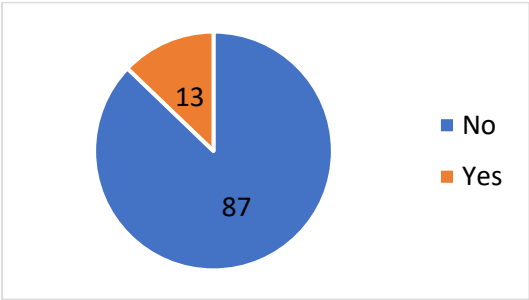


Figure 1: Awareness of consumers about cashew juice in Benin (% of surveyed consumers)

Source: Own compilation based on survey data.

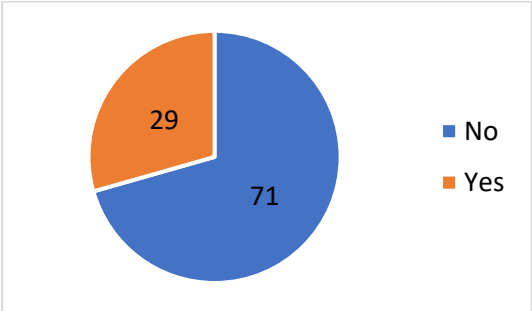


Figure 2: Ever consumed cashew juice (% of consumers aware of cashew juice)

Source: Own compilation based on survey data.

2.4.4. Results: Final consumer valuation of cashew juice in the experimental auction (round 3)

Propensity of buying and maximum proposed price

After seeing, tasting and discussing the cashew juice during the auction sessions, more than 95% of the participants decided to buy cashew juice 1 (natural flavored) and more than 90% decided to buy cashew juice 2 (caramel flavored) (Figure 3). This shows that if consumers knew about the cashew juice, many would buy it. Thus, communicating the existence of cashew juice would support its consumption.

Those who decided to buy proposed the maximum price they were willing to pay. WTP is from FCFA 1000 to 2400 with an average of FCFA 1289 for one liter of natural flavored juice and from FCFA 940 to 4000 (average FCFA 1317) for a liter of caramel flavored juice (Table 5).

On the market, the wholesale price is FCFA 1083.33/l while the retail price is FCFA 1400/l. More than 40% of consumers willing to buy cashew juices are willing to pay at maximum a price in the interval between the observed wholesale and retail price (FCFA 1083-1400) (Figure 4). Almost 30 % are willing to pay less and almost 30% are willing to pay more than these market prices. The 30% willing to pay more than the market price will be easy to convince when the product will be available on a large scale. And the 40% willing to pay in the range of market prices may be attracted, especially when large-scale production would result in lower prices due to economies of scale.

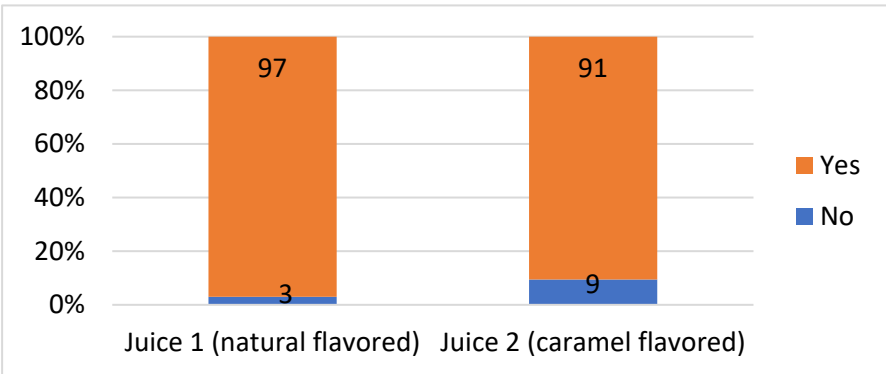


Figure 3: Propensity to buy cashew juice in Benin (% surveyed consumers)

Source: Own compilation based on survey data.

Table 5: Descriptive statistics of the maximum price proposed for each juice

Juice	Descriptive (FCFA/l)			
	Mean	Std. Dev.	Min	Max
Juice 1 (natural flavored)	1288.6	321.4	1000.0	2400.0
Juice 2 (caramel flavored)	1317.2	435.9	940.0	4000.0

Source: Own compilation based on survey data.

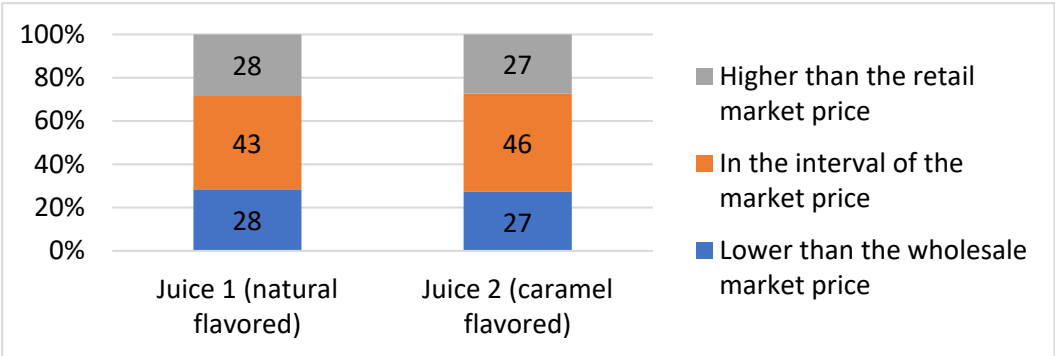


Figure 4: Consumer proportion according to the maximum price proposed (% consumers willing to buy)

Source: Own compilation based on survey data.

Premium to taste and Word-of-Mouth (WOM)

The descriptive statistics of the total final price premium as well as taste and WOM premiums are reported in Table 6. In general, consumers from central and northeastern parts of Benin are willing to pay higher prices for cashew juice (Table 6). These two regions produce about 70% of the total cashew production in Benin. Consumers from these regions know about cashews and the value of cashew apples since they live in a production environment.

Even though the significance levels of the t-test of means comparison are not very high, one can see from these statistics that consumers in urban areas tend to pay higher prices for both juice types (natural flavored and caramel flavored). Consumers in rural areas pay higher prices for natural flavored juice, while urban consumers pay higher prices for caramel flavored juice. Rural consumers justify their premiums and propensities to buy natural flavored juice by the fact that its taste is closer to the raw cashew apple, while urban consumers justify their choice by the fact that the caramel flavored juice tastes more refined.

The premiums by region also show that, in central and northeastern parts of Benin, consumers are willing to pay more for the natural flavored juice. As these two regions produce most of the cashew in Benin, consumers from these regions know the cashew apple and its natural taste, which is best reflected in the natural flavored juice. They are therefore attached to that taste and (believe more) are more convinced of the quality of this juice. The trend is the opposite in the southern and northwestern parts of Benin. These consumers know less the raw cashew apple taste and are therefore more attached to the refined product. Therefore, they pay higher premiums for caramel flavored juice.

Overall, after seeing the two cashew juice types, consumers react positively to their taste by paying higher post-sensory premiums (Table 6). Consumers are thus not disappointed by the taste of the cashew apple juice. Only rural consumers from northwest Benin pay a negative average taste premium to natural flavored juice.

Apart from the northwest region, the taste premium for the natural flavored juice is higher than for the caramel flavored juice in rural areas. Urban consumers are only willing to pay higher taste premiums for natural flavored juice in northeastern Benin. For Benin urban consumers, the taste of caramel flavored juice exceeded their expectations while the taste of the natural flavored juice fit their expectations well. Rural consumers, in contrast, seem proud

of the natural flavored juice as it tastes more or less like the raw cashew apple. Therefore, they pay a higher taste premium for it.

Consumers react to the discussion with peers by paying a post-discussion premium either higher or lower than the premium they pay in the post-sensory round (Table 6). This shows that Word-Of-Mouth (WOM) communication influences consumer behavior. In most cases, consumers react highly to cashew juice taste by paying relatively high premiums. In general, they are willing to pay more than the market price. However, the discussions with peers allow them to better analyze the potential price of such a product and to propose lower premiums closer to the market price. Only consumers in northeastern Benin are willing to increase their premiums after discussing with their peers. Therefore, the WOM premium is positive in that region and marketing strategies to promote cashew apple juice in Benin can thus use WOM communication strategies.

Table 6: Descriptive statistics of price, taste and WOM premiums

Regions	Juices upgrade	Total final price premium ^a (% of benchmark price)								Taste premium ^b (% of benchmark price)								WOM premium ^c (% of benchmark price)							
		Rural		Urban		Region		t-test#	Rural		Urban		Region		t-test#	Rural		Urban		Region		t-test#			
		Mean	SD	Mean	SD	Mean	SD		Mean	SD	Mean	SD	Mean	SD		Mean	SD	Mean	SD	Mean	SD				
South	Juice1 (Nat. flav.)	20.3	22.5	25.7	26.1	22.8	24.2	-1.0 ^{ns}	3.8	28.4	7.6	21.8	5.7	25.2	-0.6 ^{ns}	-5.0	20.1	-1.0	17.5	-3.1	18.9	-0.9 ^{ns}			
	Juice2 (Car. Flav.)	25.1	25.7	23.9	27.6	24.6	26.4	0.2 ^{ns}	2.8	31.2	9.5	30.5	6.3	30.7	0.8 ^{ns}	-8.1	20.0	-6.7	25.2	-7.5	22.3	-0.2 ^{ns}			
Centre	Juice1 (Nat. flav.)	48.8	45.7	50.4	43.2	49.6	44.1	-0.1 ^{ns}	16.7	46.5	20.7	34.6	18.8	40.3	-0.4 ^{ns}	-9.2	38.7	-6.3	25.8	-7.6	32.2	-0.4 ^{ns}			
	Juice2 (Car. Flav.)	45.4	42.0	79.5	74.3	65.1	64.5	-2.1 ^{**}	5.0	23.3	38.3	68.4	24.1	56.2	-2.4 ^{**}	-5.8	30.6	-10.6	67.0	-8.5	54.3	0.3 ^{ns}			
Northeast	Juice1 (Nat. flav.)	59.8	40.8	38.1	21.7	48.4	33.7	2.6 ^{***}	17.3	17.9	8.8	12.1	11.1	14.1	1.5 [*]	2.7	10.4	4.4	20.1	3.6	16.1	-0.4 ^{ns}			
	Juice2 (Car. Flav.)	41.6	30.5	38.5	25.4	40.1	27.9	0.4 ^{ns}	0.5	39.2	1.6	23.8	1.3	28.0	-0.1 ^{ns}	0.2	7.8	7.3	27.3	3.7	20.1	-1.3 [*]			
Northwest	Juice1 (Nat. flav.)	23.1	26.0	32.8	12.1	28.1	20.4	-1.8 ^{**}	-0.6	24.5	13.7	17.0	7.0	21.9	-2.6 ^{***}	-4.3	16.4	-10.1	33.7	-7.3	26.7	0.8 ^{ns}			
	Juice2 (Car. Flav.)	31.5	62.1	32.8	23.3	32.1	46.8	-0.1 ^{ns}	9.2	45.3	27.0	51.6	18.2	49.0	-1.3 [*]	-2.4	7.8	-31.1	82.0	-16.5	59.0	1.8 ^{**}			
Benin	Juice1 (Nat. flav.)	37.0	38.1	37.2	30.1	37.1	34.2	-0.1 ^{ns}	7.7	34.1	13.3	24.3	10.8	29.2	-1.4 [*]	-4.2	24.1	-3.3	25.2	-3.7	24.7	-0.3 ^{ns}			
	Juice2 (Car. Flav.)	34.9	41.8	45.3	50.1	40.1	46.4	-1.7 ^{**}	5.2	34.4	21.1	50.9	14.1	45.1	-2.5 ^{***}	-4.3	18.8	-10.2	57.1	-7.3	42.6	1.1 ^{ns}			

Notes a: WTP post-discussion/benchmark price (FCFA 940/l=US\$ 1.5/l), b: (WTP post-sensory- WTP pre-sensory)/benchmark price, c: (WTP post-discussion- WTP post -sensory)/benchmark price

#: Student t test of mean comparison, ns: non-significant (P≥0.1), * :0.1<P≤0.05, ** :0.05<P≤0.001, ***:P<0.001

Nat. flav.: natural flavored, Car. flav.: natural flavored

Source: Own compilation based on survey data

Propensity of changing drinking habits

Table 7 shows the propensity of consumers to replace their currently consumed drinks with cashew juice. When Benin consumers start consuming cashew juices, more than 80% of those consuming soda proclaim that they will replace their consumption of soda with cashew apple juices. Likewise, almost 70% of those consuming other domestic juices will substitute a share of their consumption of these other domestic juices while more than 70% of those consuming imported juice announce to decrease this consumption and replace it cashew juices. The shares are lower for alcohol consumers but more than half of them proclaim to replace a share of their alcohol consumption with cashew juices.

Table 7: Consumer decision to replace current drinks with cashew juice

Decision	% of consumers consuming									
	Other domestic juices		Imported juices		Soda		Beer		Other alcohol	
	Juice 1	Juice 2	Juice 1	Juice 2	Juice 1	Juice 2	Juice 1	Juice 2	Juice 1	Juice 2
No	32	32	28	28	15	19	44	48	40	40
Yes	68	68	72	72	85	81	56	52	60	60

Source: Own compilation based on survey data.

Consumer choices for cashew apple juice

In general, consumers show a higher preference for natural flavored juice (Table 8): as much as 54% of consumers prefer the natural flavored juice. This preference for the natural flavored juice is more pronounced in urban areas (57%) than in rural areas (52%). In the northwest region, however, more consumers in rural areas prefer the natural flavored juice than in urban areas (in relative terms).

In southern and central regions, the preference is higher for caramel flavored juice. This preference is more pronounced in rural areas while the preference for the natural flavored juice is more pronounced in urban areas with the consumers in the urban central part of Benin preferring more the juice natural flavored than the caramel flavored juice.

We did a Pearson Chi square test of independence to see if there is any statistically significant difference in the percentage of people preferring the two juice types across rural and urban areas. These tests show no significant difference in any of the four regions, nor in Benin as a whole. Therefore, we consider the market as segmented for the two juice types.

Table 8: Consumer choices for cashew apple juice

Regions	Juices	Consumers' choice for the cashew apple juice (% consumer)			Chi ² test [#]
		Rural	Urban	Region	
South	Juice1 (Natural flavored)	44.4	47.5	46.1	0.07 ^{NS}
	Juice2 (Caramel flavored)	55.6	52.5	53.9	
	Total	100.0	100.0	100.0	
Centre	Juice1 (Natural flavored)	40.0	58.1	48.5	0.14 ^{NS}
	Juice2 (Caramel flavored)	60.0	41.9	51.5	
	Total	100.0	100.0	100.0	
Northeast	Juice1 (Natural flavored)	61.3	69.0	65.0	0.39 ^{NS}
	Juice2 (Caramel flavored)	38.7	31.0	35.0	
	Total	100.0	100.0	100.0	
Northwest	Juice1 (Natural flavored)	64.5	55.2	60.0	0.55 ^{NS}
	Juice2 (Caramel flavored)	35.5	44.8	40.0	
	Total	100.0	100.0	100.0	
Benin	Juice1 (Natural flavored)	51.9	56.6	54.2	0.59 ^{NS}
	Juice2 (Caramel flavored)	48.1	43.4	45.8	
	Total	100.0	100.0	100.0	

Notes #: Chi square test of independence following urbanization, ns: non-significant (P≥0.1)

Source: Own compilation based on survey data.

2.4.5. Implications for cashew sector development

The large majority of consumers are willing to buy cashew apple juice and pay for it at current market prices. In general, willingness to pay increases after tasting the juices. These results show that a potential for cashew apple juice exists. Therefore, a communication campaign throughout the country to invite people to taste cashew apple juice has a strong potential to increase consumption. Those who have tasted will talk about it to other people raising awareness and demand. The ministries of agriculture and industries may therefore consider setting up a joint promotional program.

Consumer choices show that the market is segmented for the two cashew juice types. Therefore, both juice types should be promoted to develop cashew apple processing.

As suggested by processors, training farmers and supporting them in acquiring presses using fuel may support sector development. It would allow the first processing step to take place on the farm as cashew apples are very difficult to transport (very fragile) and thus reduce losses. The factories

could collect the liquid (pulp) for further processing. Such an organization of the value chain needs confidence between farmers and processors as well as suitable contracts.

3. Economy-wide effect of processing development for poultry and cashew by-products in Benin

3.1. Disaggregation of an existing SAM for Benin

We developed a 2019 SAM for Benin (Kinkpe *et al.*, 2022) with a high degree of disaggregation of agriculture and the food processing sector. This SAM is a snapshot of Benin's economy as a whole and the transactions between different institutions in a given year. For the purpose of this study, this SAM was further disaggregated. The final SAM used for simulations contains 129 accounts:

- 48 activities: 21 agricultural, mining, 11 food industry (including cashew apple processing, cashew nut processing and two poultry slaughtering activities), 7 non-food industry, construction and 7 service-providing activities;
- 3 margins: domestic trade, import and export;
- 51 commodities: 22 agricultural, mining, 12 food industry, 9 non-food industry, construction and 6 services;
- 8 production factors: 2 labor (unskilled and skilled), 3 capital (agricultural, non-agricultural and stable electricity network), 3 land (annual crop land, permanent crop land and animal husbandry land);
- 13 institutional accounts: enterprises, 10 private household groups (5 rural income quintiles and 5 urban income quintiles), government and the rest of the world;
- 6 tax accounts (direct tax, production tax, value-added tax, sales tax, import tariff and export tax) and
- one saving-investment account.

The use of cashew processing by-products (cashew nutshell) to produce bio-energy is depicted in the SAM. The cashew activity is disaggregated into two activities: one producing only the cashew nut and the second producing both the cashew nut and the cashew apple considering the current use of cashew apples.

3.2. CGE development and scenario analysis

The SAM described above is used for a CGE analysis based on the Static Applied General Equilibrium model STAGE (McDonald, 2015). We develop scenarios based on the findings from the empirical studies described in Section 2 and compare them to the model base for the year 2019.

3.2.1. Scenario development

As the background story and the empirical evidence differ between cashew and poultry processing, we followed a different logic for scenario development.

Scenarios regarding poultry processing

According to poultry processors, the domestic demand for poultry meat is high and expanding. They argue that the government should promote local poultry meat to reach a preference shift from imported to local poultry meat. For that, they suggest that the government uses communication/marketing strategies to inform and convince consumers to shift their preference and tax imported poultry meat to make it more expensive. They also suggest enhancing extension services to poultry farmers to improve production technologies (local breeds, feeding and care).

Assuming that the government takes such measures, we simulate a shift from imported poultry meat to local poultry meat by shifting 11.7 thousand tons (about 30% of total poultry meat demand, see Table 1) of household demand for imported broiler poultry meat (in the base situation) to the local poultry meat (bicycle), which is known as healthier and preferred by consumers for its taste (Kulla *et al.*, 2021). Furthermore, we assume that with the development of the local poultry processing sector, local poultry farming will be more productive because of learning by doing (dynamic economies of scale). With the same housing, labor, and equipment, more poultry meat will be produced. Therefore, we simulate a 10% increase in productivity. This scenario is called PrefShift. On top of that, we simulate doubling the import tariff rate on imported frozen poultry meat from 7.5% to 15% (PrefShift_Tariff). The details of the two scenarios are presented in Table 9.

Table 9: Scenarios for poultry meat

Scenario	Change in household demand for bicycle poultry meat (thousand tons)	Change in household demand for broiler poultry meat (thousand tons)	Change in total productivity of poultry farming (%)	Change in Import tariff rate on frozen poultry meat
PrefShift	+11.7	-11.7	+10	
PrefShift_Tariff	+11.7	-11.7	+10	+7.5%

Source: Own compilation based on survey data.

Scenarios regarding cashew by-product processing

97% of the consumers from whom we collected data are willing to buy cashew apple juice if it is available for the consumption in their household (see Figure 3). Currently, 3.8% of these consumers are consuming cashew apples in their households (figure deducted from figures 1 and 2). Considering the size of their households, this is approximately 3% of the total sample (considering the household size).

The cashew apple processors are asking for government support to make the population aware and to promote cashew apple juice. In our first scenario, we assume that this support works and 97% of the population consumes cashew apple juice. We furthermore assume that the average per capita consumption of cashew apple juice increases from 0.13 l/year to 0.53 l/year (derived from the experimental auction). On top of that, we consider the substitution effect. About 52% of the consumers willing to buy cashew apple juice stated that they will substitute other drinks (see Table 7). Considering their household size, this is about 50%. We then simulate that 50% of the increase in cashew apple juice demand is a substitution from alcoholic drinks (5% because of low substitutability between juice and alcohol) and sodas (45%, because of high substitutability and high willingness to substitute). The scenario with the complete demand shock is called DEMAND.

Farmers and processors suggest government support to develop the cashew apple processing sector. As 98% of the produced cashew apple spoils under the trees, we target in a second scenario support from the government to develop the cashew apple processing sector to process 100% of the produced apple. On top of the DEMAND, the government subsidizes the sector in this scenario. This support generates more demand for the cashew apple for processing, which stimulates the use of the wasted cashew apple. This scenario is called DEMAND_supwaste. We let the subsidy rate in the model adjust allowing full employment of the cashew apple. The subsidy rate needed

to achieve the full use of the cashew apple is about 12.6%. The details of both scenarios are presented in Table 10.

Table 10: Scenarios for cashew apple processing

Scenarios	Change in household demand for cashew apple juice (thousand tons)	Change in household demand for sodas (thousand tons)	Change in household demand for alcoholic drinks (thousand tons)	Production tax rate in cashew apple processing
DEMAND	+201.1	-90.5	-10.1	-0%
DEMAND_supwaste	+201.1	-90.5	-10.1	-12.6%

Source: Own compilation based on survey data.

3.2.2. Closure rules

As Benin belongs to the West-African Economic and Monetary Union (WAEMU) using a currency called FCFA, which is pegged to Euro with a fixed parity, we use a fixed Exchange Rate (ER) closure with a flexible trade balance.

The two labor categories (skilled and unskilled) are modeled as fully mobile for the poultry sector simulations. As cashew is harvested during the dry season, when agricultural labor is unemployed, the unskilled labor is 8% modeled as unemployed for the simulations on cashew sector development while skilled labor is also fully employed. Capital is fully mobile within a sector but cannot move from one sector to another. For that, we distinguish three sectors: agriculture, stable electricity and other sectors.

The land is also fully mobile within a sector but is specific to that sector. For that, we distinguish annual crops, permanent crops and animal husbandry land. The permanent crop land is modelled as unemployed for 40%.

The model is savings driven with a fixed investment share in total demand. The internal balance (government savings) is fixed and the income tax rate on households is flexible to collect more tax from high-income households to finance policies or subsidize poor households if the policy implementation generates a surplus.

The Consumer Price Index (CPI) is the numeraire in the economy (fixed). Benin is assumed to be a small country (fixed world market prices).

3.3. Economy-wide effect of preference shift from imported frozen poultry meat to local poultry meat in Benin

3.3.1. Demand and consumer price effects

The preference shift of consumers increases the domestic demand for bicycle poultry meat by about 13 thousand tons and lowers the domestic demand for broiler poultry meat by about the same quantity (Figure 5). As an intermediate input to bicycle poultry meat, the domestic demand for bicycle poultry increases accordingly while the demand for broiler poultry itself decreases accordingly.

The price of bicycle poultry meat decreases because of lower bicycle poultry price and the broiler poultry meat price decreases because of lower demand (under PrefShift) (Figure 6). The price of bicycle poultry decreases because of higher productivity in poultry farming which more than compensates for the effect of higher demand for bicycle poultry. The broiler poultry price increases because of the increasing price in agricultural capital (Figure 11), which results from the productivity increase in bicycle poultry. With a double import tariff (under PrefShift_tariff), the broiler meat price increases accordingly as most of it is imported.

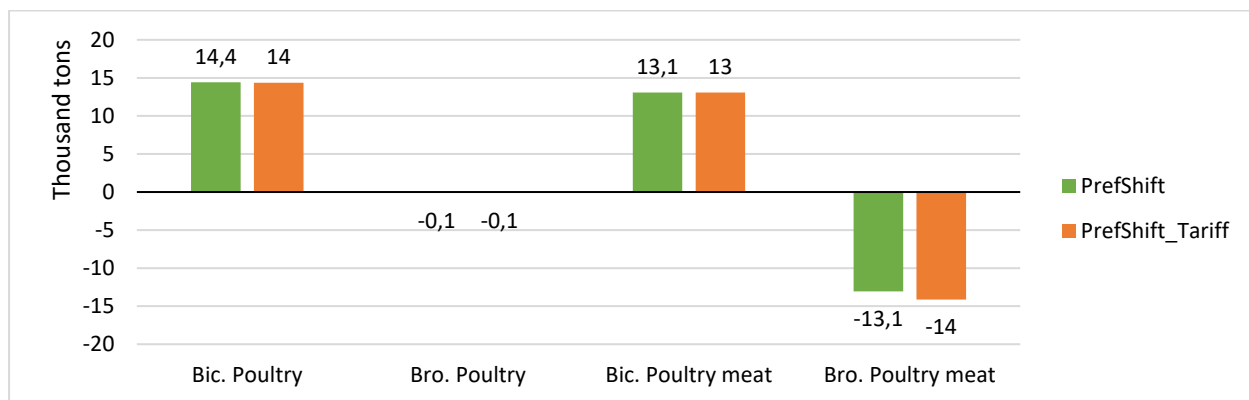


Figure 5: Domestic demand change (1000 tons)

Source: Own compilation based on simulation results.

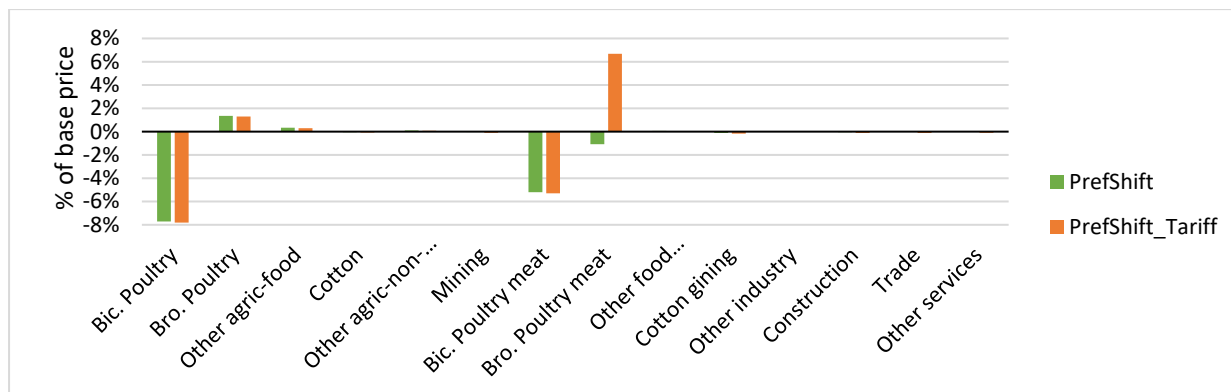


Figure 6: Domestic consumer price change (%)

Source: Own compilation based on simulation results.

3.3.2. Production and cost effects

With the preference shift from broiler poultry meat (mostly imported) to bicycle poultry meat (domestically produced), the bicycle poultry meat production increases by about 16 thousand tons in comparison with the base (Figure 7) and the broiler poultry meat declines by about 40 tons. Accordingly, bicycle poultry production is 15 thousand tons higher and broiler poultry production is slightly lower.

Doubling the import tariff on broiler poultry meat has a small positive effect on broiler poultry meat production (the broiler poultry meat production declines less than under preference shift) because of a higher import decrease. In general, the production of other commodities declines slightly because of competition for production factors (Figure 8).

The bicycle poultry meat price declines because of higher productivity and the broiler poultry meat price declines because of lower demand (Figure 9). In contrast, the broiler poultry meat price increases under the doubled import tariff because of the imported meat used as an intermediate input in the broiler poultry meat production by the “service activity of broiler poultry meat import-export” (smuggling to Nigeria).

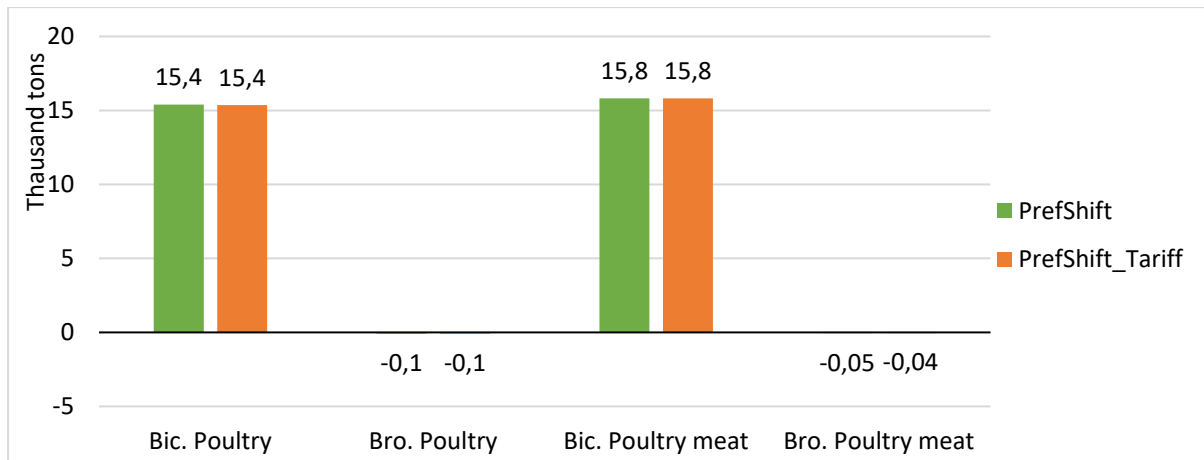


Figure 7: Production change for the targeted commodities (1000 tons)

Source: Own compilation based on simulation results.

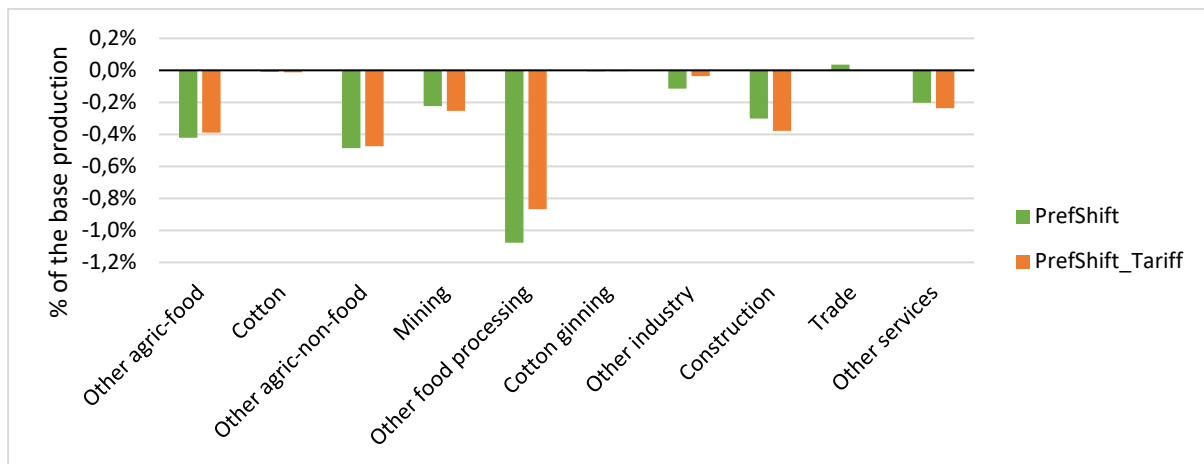


Figure 8: Production change for other commodities (%)

Source: Own compilation based on simulation results.

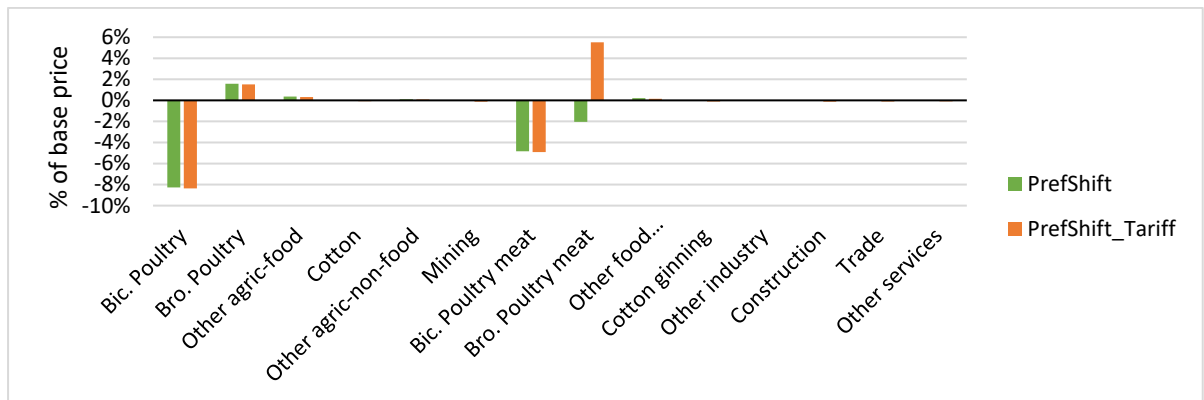


Figure 9: Producer price change (%)

Source: Own compilation based on simulation results.

3.3.3. Trade effects

With the shift in consumer preferences, broiler poultry meat imports decline by more than 50%. Accordingly, broiler poultry meat exports, of which a large part consists of imported poultry meat (from the Global North) illegally smuggled to Nigeria (USDA, 2014), declines by about 2.4 thousand tons (Figure 10). This export is replaced by the export of domestic bicycle poultry meat, which is about 1.5 thousand tons higher. The export of bicycle poultry itself increases because of higher production.

As smuggling from Benin to Nigeria has been for long a factor of discordance between the two countries, higher production and export of a domestically produced food product can be considered as an element of a good trade relationship between the two countries, which are naturally big trading partners with about 800 km of shared border.

The trade deficit declines by 9% under PrefShift and 11% under PrefShift_Tariff as imports decline more under the higher import tariff.

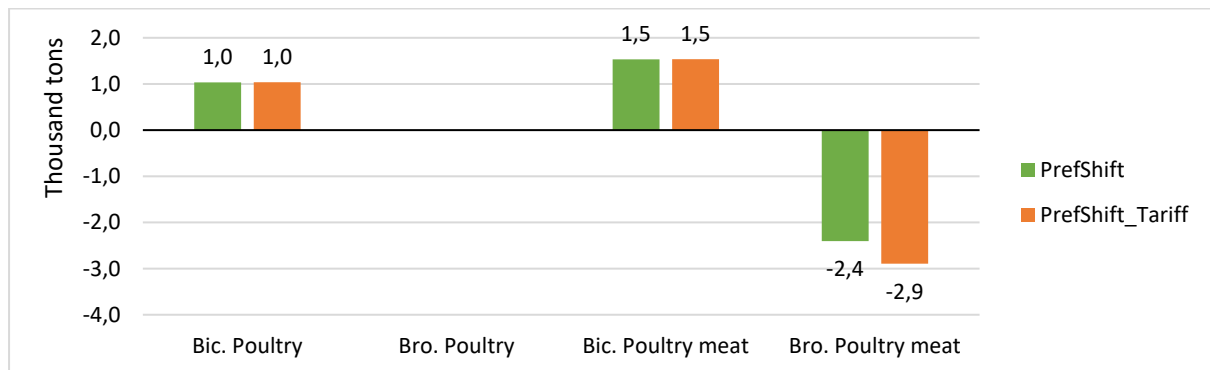


Figure 10: Export change (1000 tons)

Source: Own compilation based on simulation results.

3.3.4. Employment and income effects

Higher production of bicycle poultry meat and bicycle poultry increases wages as well as prices of agricultural capital and land used in animal husbandry (Figure 11). Accordingly, income paid to

these factors increases. This results in more income for households owning labor and agricultural capital.

Low-income quintile households in rural and urban areas gain income with the urban areas gaining more in relative terms (Figure 12) because the skilled labor price increases more than the unskilled labor price. Despite the agricultural capital price increasing by almost 6%, it represents only 2% of rural household income and less than 1% of urban household income. Its effect is dominated by labor wages representing 54% and 49% of urban and rural household income, respectively. In addition, apart from husbandry land, all land prices decline, lowering income effects on rural households which have more income from land than urban households.

High-income quintile households in both rural and urban areas lose income under PrefShift_tariff (Figure 12), mainly due to the higher decline of the price of non-agricultural capital, which provides the highest share of their income.

In general, the income effect is higher in urban areas than in rural areas (Figure 12) because the skilled labor price rises more than the unskilled labor price and most of the skilled labor belongs to urban households.

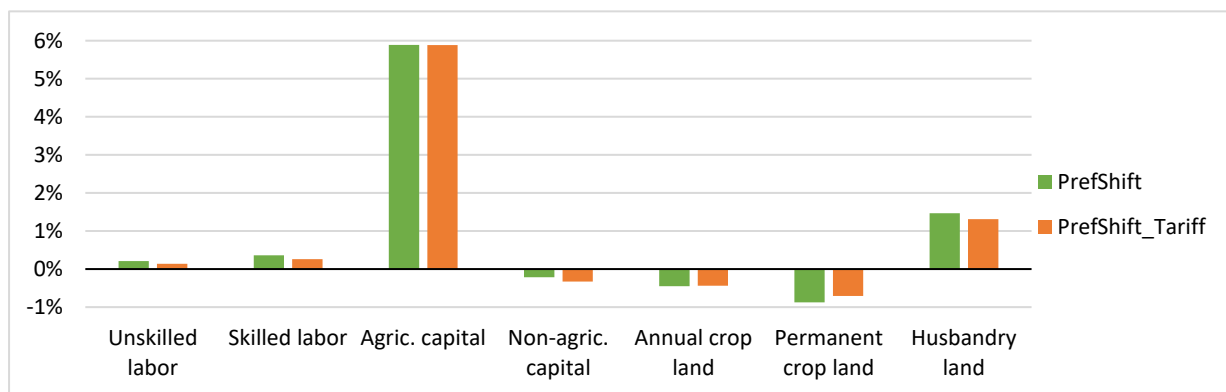


Figure 11: Factor wage changes (%)

Source: Own compilation based on simulation results.

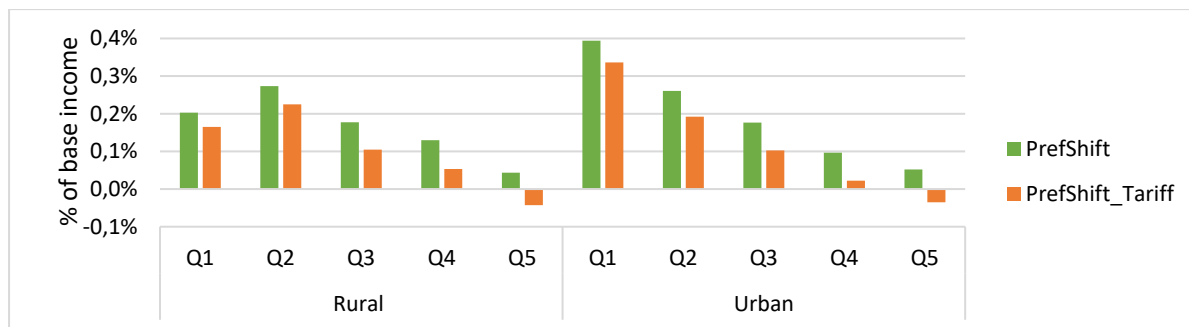


Figure 12: Household income changes (%)

Source: Own compilation based on simulation results.

3.3.5. Nutrition and sustainability of the food system

A substantial share of imported frozen poultry meat consumption is replaced by meat from local poultry breeds. With just a preference shift from imported poultry meat to local poultry meat, poultry meat consumption increases by 1.8% or 0.05 kg per capita and year, resulting in a better provision of protein. This quantity is small. However, as a shock, we just shift consumer preferences from one product to another. The slight consumption increase is thus only an indirect effect. Furthermore, as poultry production increases, beef production declines by 1.3%, resulting in lower beef consumption. Considering that the actual per capita poultry meat consumption in Benin is lower than the requirement for a healthy diet (Willett *et al.*, 2019) and that beef consumption is higher than that requirement, one can argue that, this preference shift effect will make the diet in Benin more sustainable. Furthermore, even if the cooling chains are insured during transportation of frozen poultry meat from its origin to its destination port, it is not known how effective the cooling chains in the destination country (Benin) are. This often affects the microbiological and nutritional quality (Dahouenon Ahoussi *et al.*, 2008). Therefore, a replacement by local poultry meat can be considered a factor for healthier diets.

3.4. Economy-wide effect of cashew by-product processing development in Benin

3.4.1. Demand and consumer price effects

The DEMAND scenario generates an additional domestic demand of about 219 thousand tons of cashew apple juice (Figure 13). This induces an additional domestic demand of more than 800 thousand tons of cashew apples. At the same time, domestic cashew nut demand increases by 56 thousand tons.

Under DEMAND_supwaste, which is aiming at reaching the full use of the cashew apple by the processing sector, domestic demand for cashew apples more than quadruples compared to DEMAND, while the domestic demand for cashew nuts is lower than under DEMAND. This induces a slightly falling price for cashew nut kernels and cashew nuts (Figure 14) because of the higher supply and a slightly increasing price for cashew apple juice because of the higher demand. The price for cashew apples almost doubles under DEMAND and more than doubles under DEMAND_supwaste because it is a product purely domestically consumed, which faces a demand boost. In contrast, cashew apple juice is almost as much exported (fixed world market price) as domestically consumed. Under DEMAND_supwaste, the cashew apple juice price falls because of the lower domestic price.

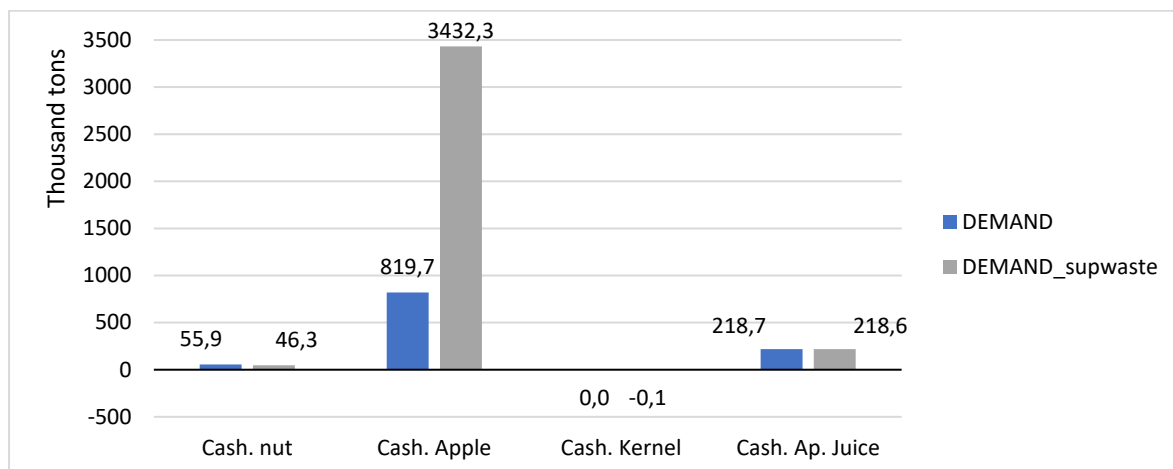


Figure 13: Domestic demand changes (1000 tons)

Source: Own compilation based on simulation results.

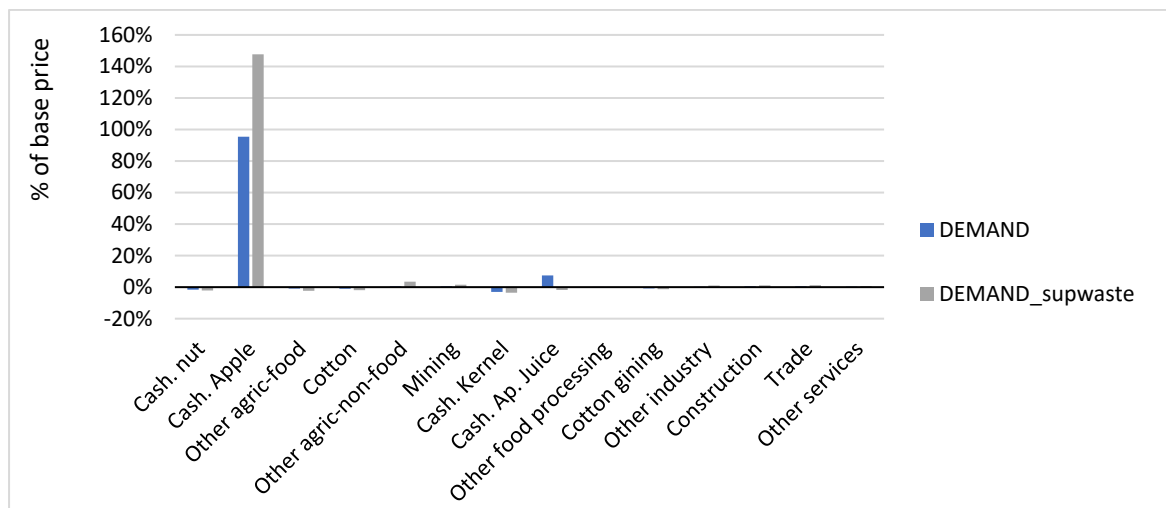


Figure 14: Domestic consumer price changes (%)

Source: Own compilation based on simulation results.

3.4.2. Production and cost effects

To satisfy the boom of domestic cashew apple juice demand (DEMAND scenario), cashew apple juice production increases by about 222 thousand tons (Figure 15), which induces an approximate increase in cashew apple production of 870 thousand tons. This makes the cashew sector more attractive and induces an increase in cashew nut production of more than 300 thousand tons.

The support of the cashew apple processing sector boosts that sector (4 times higher than under DEMAND). The cashew sector becomes more attractive, demanding more factors and generating an additional production of about 280 thousand tons of cashew nut equivalent to doubling base production.

Production of other sectors declines slightly (Figure 16) because of competition with the cashew sector for factors (non-agricultural capital for the industrial sectors and agricultural capital for the agricultural sectors). Only industries (other industries) providing a substantial share of intermediate inputs to the cashew processing sectors and trade also increase production.

The cashew apple juice producer price increases substantially (7%) under DEMAND (Figure 17) and the cashew apple producer price almost doubles under that scenario because of increasing demand. This means higher income for cashew farmers. Prices of other commodities decrease or increase slightly because of supply or demand effects generated by the boost in the cashew sectors.

The mining and construction sectors decline more than other sectors because of non-agricultural capital movement to cashew apple processing, as these two sectors are highly capital intensive.

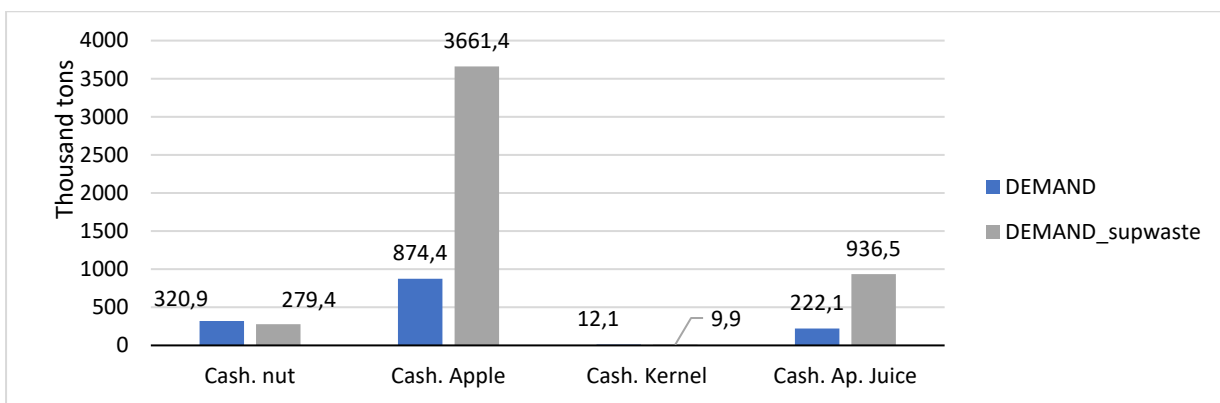


Figure 15: Production changes for the targeted commodities (1000 tons)

Source: Own compilation based on simulation results.

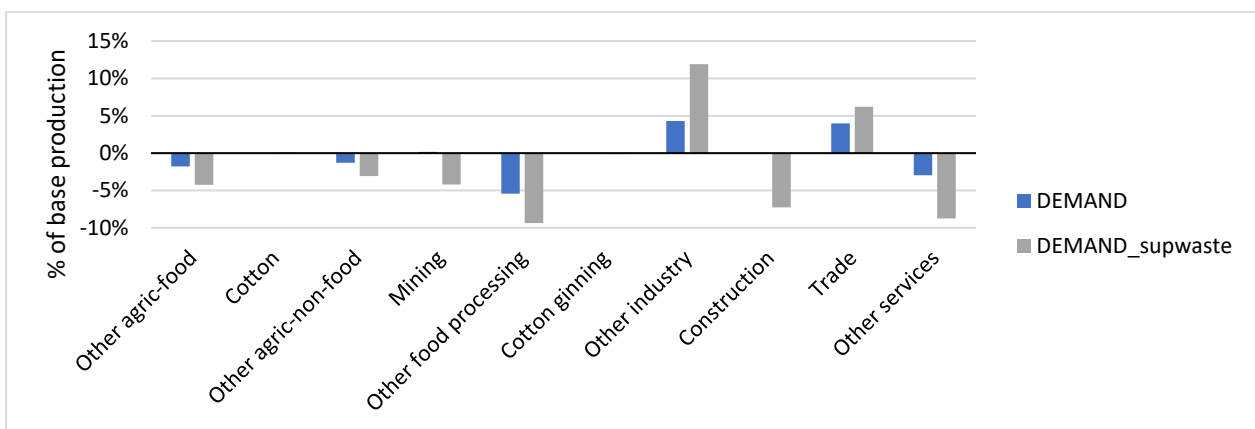


Figure 16: Production changes for other commodities (%)

Source: Own compilation based on simulation results.

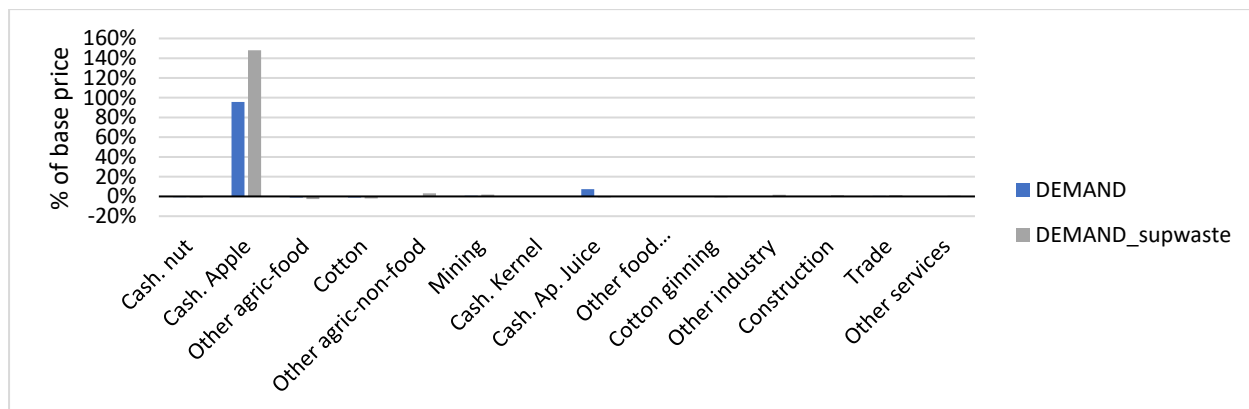


Figure 17: Producer price changes (%)

Source: Own compilation based on simulation results.

3.4.3. Trade effects

In the base situation, more than 80% of raw cashew nuts are exported. That background translates into high export increases (about 265 thousand tons) for raw cashew nuts under DEMAND (Figure 18) (more than 80% of the production generated). The additional cashew kernel exported is almost the same as the additional production, as it is an almost fully exported product.

The export of cashew apple juice increases only by 0.7 thousand tons under DEMAND (Figure 18) because of the boom in domestic demand while under DEMAND_supwaste, the export increases by more than 700 thousand tons. We also ran an intermediate scenario of support without demand shock and most of the additional supply was exported.

The export boom under DEMAND_supwaste reverses the economy's trade deficit: the trade deficit of about FCFA 317 billion in the base becomes a trade surplus of about FCFA 270 billion under DEMAND_supwaste.

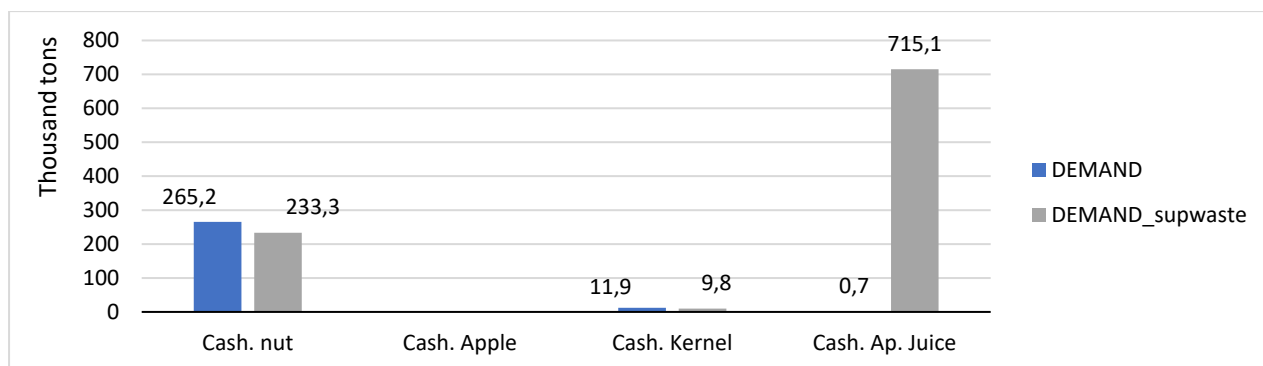


Figure 18: Export changes (1000 tons)

Source: Own compilation based on simulation results.

3.4.4. Employment and income effects

As cashew is harvested in the dry season in Benin, it uses to a large extent agricultural labor being unemployed otherwise in the dry season. This explains the constant price for unskilled labor in the simulations (Figure 19). Mainly female labor is used for harvesting and, as observed in the field, most of those working in cashew apple processing are female, too. In conclusion, the development of cashew apple processing will reduce unemployment of agricultural labor, especially in the dry season. As this labor essentially belongs to women, women's autonomy/independence will be reinforced through a more equitable income distribution.

Agricultural capital, non-agricultural capital and permanent crop land used in the targeted sector become more valuable and their wages increase (Figure 19). They increase in value also because of the relative abundance of unskilled labor. Accordingly, all household groups gain additional income with rural households benefitting more than urban households (Figure 20). In addition, the distribution of income changes is pro-poor showing a poverty reduction potential through cashew apple processing sector development.

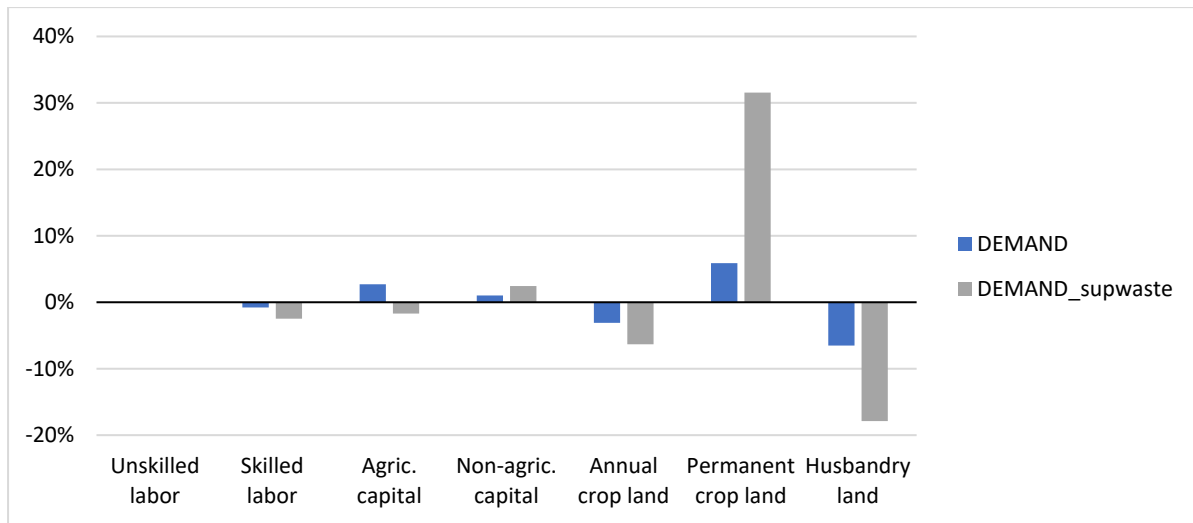


Figure 19: Factor wage changes (%)

Source: Own compilation based on simulation results.

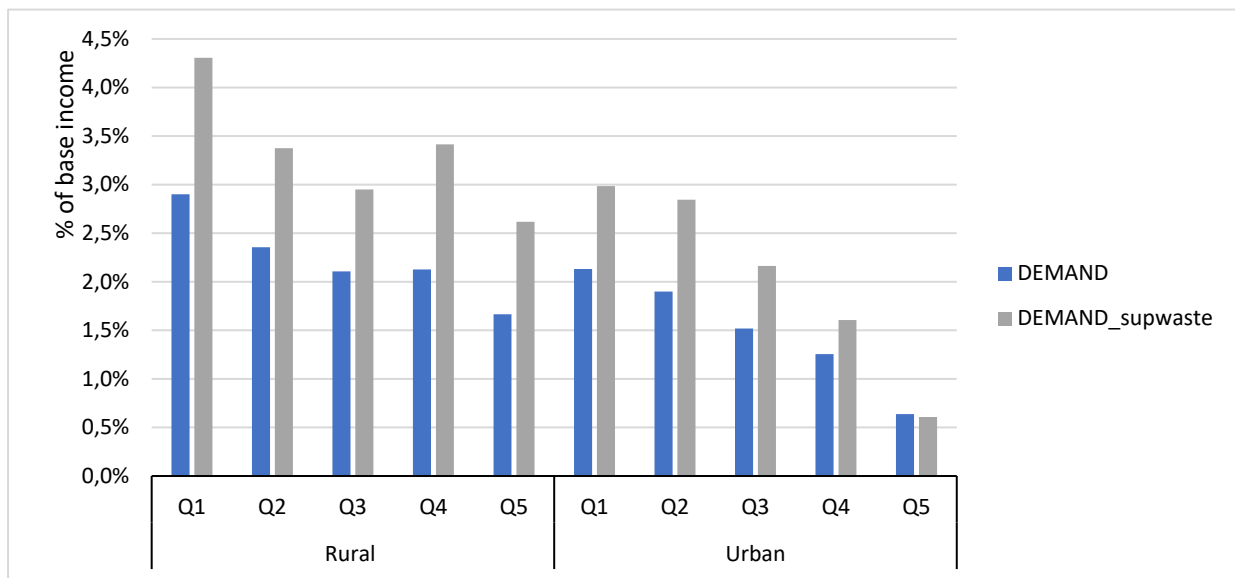


Figure 20: Household income changes (%)

Source: Own compilation based on simulation results.

3.4.5. Macroeconomic effects

As a consequence of higher production and lower waste, GDP at factor cost increases (Figure 21).

Total exports increase almost four times more than total imports under DEMAND and almost five

times more than total imports under DEMAND_supwaste. Accordingly, the trade deficit declines by 34% under DEMAND and turns into a trade surplus under DEMAND_supwaste.

Total absorption (domestic demand) under DEMAND_supwaste declines because of an almost 50% increase in total household savings to keep the total investment quantity as a fixed share of total demand in the situation of declining foreign capital imports, reflecting the change in the trade balance. As household savings constitute future purchasing power, one can consider the savings effect as compensation for the negative absorption effect. Even with the higher income tax raised to finance the DEMAND_supwaste policy (0.4 to 2.2 percentage point increase in income tax rate for high-income households), the total income effect is positive for all household groups. The disposable income effect is negative (-1.7%) for the richest urban household group paying the highest income tax rate.

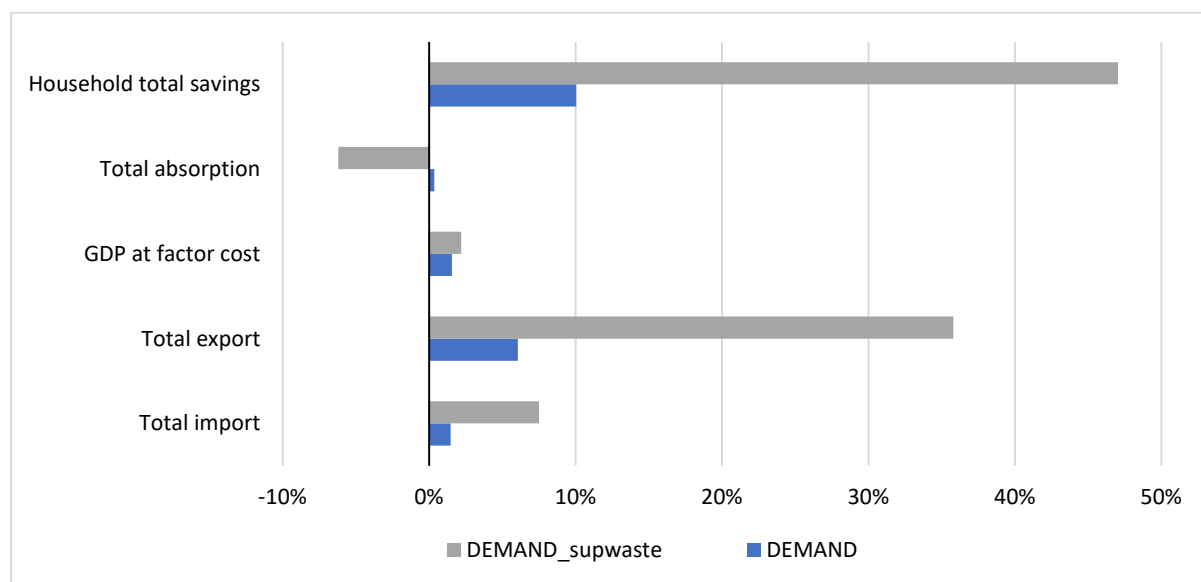


Figure 21: Macroeconomic indicators' change (%)

Source: Own compilation based on simulation results.

3.4.6. Population nutrition and sustainability of the food system

Higher consumption of highly nutritious juice and lower consumption of sodas contributes to more healthy nutrition. Currently, only 2% of the cashew apple is used in Benin. 98% of total production is simply wasted. With the cashew apple processing development under DEMAND, 21% of the total

waste is processed in addition to the additional production generated. This generates additional income for farmers. Under DEMAND_supwaste, 100% of the waste is processed on top of the additional production.

The Cashew nutshell is the most important residue obtained from the cashew nut after extracting the kernel. This shell rich in green energy causes environmental pollution if not well treated. It is currently in use in Benin to produce Cashew Nut Shell Liquide (CNSL), which is used in the paint industry. Moreover, the char obtained after CNLS extraction is generating green energy for the industrial sector. We take these realities into account in our simulations. The results show that with the expansion of cashew apple processing, the cashew nut sector also gets more attractive. More cashew nuts are processed and the cashew nutshell production more than triples. This is used to produce CNSL (mostly exported) and bio-energy, which is used in factories. Therefore, the cashew sectors become more integrated and sustainable as a whole. In addition, this by-product use makes the sectors more competitive because it generates additional income for the factories.

4. Human capacity building

Through the funds of the project, we financed the research of two students in Benin for their master completion. One of them (Ulrich AKATE, processing technology) worked on cashew apple processing while the second (Narcisse OLOUOSSA, agribusiness) worked on poultry processing. Scientific publications acknowledging funding from FSEC are expected.

The student who worked on cashew apple processing finished his thesis already and defended it on 16.12.2022. He is now working on publications based on his thesis.

The second student also finished his fieldwork and is currently writing the first draft of his thesis. The defense will probably be in June 2023.

The following boxes show a short report from each student.

Box 1

Few people are investing in poultry processing right now in Benin. According to them, it is necessary to: i) feed the population of Benin with healthy meat without preservatives; ii) advertise the quality of domestic poultry meat, iii) make consumers favor the higher priced domestic meat, iv) and to develop a strong marketing strategy to convince the local and sub-regional market.

The demand for domestic poultry meat is low since consumers prefer imported frozen poultry meat instead of domestic poultry meat because of the price.

Regarding duck meat, 80% of respondents do not process duck because its demand is really low. However, consumers would be interested in this meat, too, if they knew about its availability.

Chicken meat is the most demanded domestic poultry meat. Processors do not manage yet to satisfy the daily increasing demand because of their processing capacity (lack of equipment, finance) and sometimes irregular supply from poultry farmers. Chicken meat is available in several ways: grilled, roasted, simply plucked (uncut, cut with bones or cut without bones) but ready to cook.

The poultry processing sector needs support from the government to develop and processors need to develop strong partnerships with retailers/consumers.

Source: Oluoossa, 2022 (translated in English by Kinkpe).

Box 2

Cashew juice production technology is practically the same in most processing units. These units are grouped together in the National Union of Cooperatives Transforming Cashew Apples of Benin (UNCTPC-B). The processing technology of cashew apples into juice is transferred within this union, which constitutes an innovation platform. This union has allowed a more equitable and easier dissemination of the technology. In addition, the equipment in different processing units is similar: a manual screw press, an expeller extractor, a pasteurizer, a cooker, two filter holders and a filler. The means of transferring and disseminating information is the training organized and subsidized by the government and Non-Governmental Organizations (NGOs) in charge of promoting the technology.

It was also noted that most of the processing units have as a main problem the lack of markets for their products.

Source: Akate, 2022 (translated in English by Kinkpe).

5. Conclusion and policy implications

This project analyzes the food processing development in the Beninese food system looking at the examples of cashew and poultry meat sectors.

5.1. On the poultry sectors

Poultry processing is taking off in Benin. Processors are willing to process more domestic poultry, but the market is highly competitive because of the high import of low-priced frozen poultry meat. The simulations show that a shift in preference from broiler poultry meat (almost a hundred percent imported) to bicycle poultry meat highly appreciated by consumers and produced domestically, contributes substantially to the domestic sector development.

Higher import tariffs have a relatively small effect. This suggests that setting up a higher tariff without working towards shifting preferences would not have strong effects on domestic production. The development of the domestic poultry processing sector makes more available a highly appreciated meat contributing to a healthier diet. Based on these results, the Benin government could:

- Provide public infrastructure and services supporting the development of domestic poultry farming and processing: education, extension services, access to credit and others.
- Strongly support a consumer preference shift toward domestic bicycle poultry meat by setting up, supporting or increasing marketing campaigns around this product;
- Set up quality standards for imported frozen poultry meat. This may result in declining imports and better opportunities for the domestic poultry sector to develop. It may be more difficult to increase import tariffs on these products because of the different regional trade agreements of which Benin is a member.
- Support the bicycle poultry farming sector to gain efficiency to increase production. If domestic bicycle poultry is not available as ready-to-cook meat, it may be difficult to achieve higher domestic demand. Moreover, higher bicycle poultry production is likely to make the sector more price-competitive because of external economies of scale.

5.2. On the cashew sectors

The development of cashew apple processing in Benin is very dynamic. In the beginning of this project, we knew that cashew apple processing was starting up. The field survey shows that it is developing now and that the development potential is still big. The raw material is available and currently perishing. Most consumers do not know about cashew apple products. Most of those who taste them want to buy them. And most of them (more than 40%) are willing to pay a maximum price close to the current market price. Almost 30% of them are willing to pay even a price higher than the market price. Therefore, more than 70% of consumers are relatively easy to convince when marketing strategies are set up adequately. Exports start and the international market is promising.

Based on the nutritional quality of cashew apples, one can conclude that higher consumption of its products will improve the overall nutritional status of Benin.

CGE simulations show that the development of cashew apple processing provides additional income to farmers and households are in general better off because of higher income from production factors. Therefore, cashew apple processing development has a poverty reduction potential.

The use of waste to generate value added makes the food system more sustainable. Moreover, the development of cashew apple processing makes the whole cashew sector more attractive and cashew nut production, processing and exports also increase. The use of by-products for energy production contributes to the sustainability of the whole system. Macroeconomically, the trade deficit declines with higher cashew processing and even turns into a surplus, if all cashew apples are processed. Based on these results the government of Benin could:

- Develop strategies to support higher domestic demand for cashew apple products. It may be interesting to set up a marketing campaign around events such as national and international workshops and conferences in Benin. In addition, communication and tasting campaigns could be organized throughout the country to increase awareness among the population about the availability of the product, its good taste and its nutritional value.

There is a widespread perception that cashew apple consumption may be dangerous if milk is consumed right after or before consuming cashew apple products. Communication efforts are needed to deconstruct this false assumption.

- Increase its support to cashew apple sector development. This may comprise the provision of public infrastructure and services such as education, extension services, access to credit and others. Training farmers and supporting (subsidizing) them in acquiring first-step cashew apple processing technology could boost the processing sector. As cashew apples are difficult to transport because of their high perishability, the factories could collect the pulp from the farms using adequate transportation means and continue processing in the cities.
- Facilitate cashew apple juice exports by informing Benin trade partners about cashew apple juice.

5.3. On human capital formation

One of the unplanned achievements of this project is the funding of two master theses in Benin. This is a contribution to human capital formation in a low-income country but also a way to contribute to scientific debates by involving engagement and creativity from young and devoted researchers.

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